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U-003-307 .19

SUGGESTED METHODS FOR STORAGE OF NEUTRALIZED RAFFINATES - (USED AS A REFERENCE IN OU1 RI)

04/09/75

POLSON CHAPMAN
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MEMO

C. R. Chapman

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NATIONAL LEAD COMPANY OF OHIO

CINCINNATI, OHIO 45239

April 9, 1975

CRC 4/11/75

SUBJECT: SUGGESTED METHOD FOR STORAGE OF NEUTRALIZED RAFFINATES

TO: C. R. Chapman

FROM: C. E. Polson

The attached is in response to your request for a proposed method of storing filter cake from ~~the residues in Pit 5.~~ REFINERY RAFFINATES.

It is suggested that we look at the dumping of several truck loads of filter cake on to a small bed of coal ash on some selected high ground to give us an idea of possible problems. Following this, we could start more detailed engineering and proceed with Briggs' slightly larger scale test and then to full scale.

Several test observations are in favor of the workability of this method of storage:

1) The water in the filter cake rises to the surface.

2) The filter cake has a high angle of repose and does not slump.

3) Shrinkage of the cake occurs as water is removed from the surface. (The dried cake volume was 41% of the wet starting material)

4) Water added to a dry cake did not result in appreciable swelling or decrepitation. The shrinkage is irreversible.

Leaching studies on dried cake would be required to determine the most effective means of control. However, this is not believed to be a big problem.

Comments, suggestions, and criticisms are requested from persons on distribution.

C. E. Polson

C. E. Polson

CEP/rhg
Attachment*
cc: W. J. Adams - R. C. Kispert - w/attachment
S. F. Audia - " "
G. G. Briggs - " "
J. H. Cavendish - " "
P. G. DeFazio - A. F. Pennak- " "
R. C. Heatherton - " "
N. R. Leist - " "
J. B. Patton - " "
R. M. Spenceley - " "

*Letter, G. G. Briggs to J. H. Cavendish, Subject: Above-grade Storage of Filtered Lime-Neutralized Raffinates, 4/3/75

CRC c1-r3

6316

CRC 4/11/75

NATIONAL LEAD COMPANY OF OHIO
Cincinnati, Ohio 45239

April 3, 1975

SUBJECT ABOVE-GRADE STORAGE OF FILTERED LIME-NEUTRALIZED RAFFINATES

TO J. H. Cavendish

FROM G. G. Briggs

PROBLEM

At present, plans are proceeding to make space available in Pit 5 for storage of the filter cake which will be generated in the next year and a half from lime neutralization of raffinates derived from the completion of the ore concentrate refining campaign. Pit 5 sludge is to be returned to Plant 8 and filtered on a rotary vacuum filter. The wet filter cake from this filtration would be returned into Pit 5 and the filtrate would be sent directly to the Miami River. As soon as possible after the startup of Pit 5 sludge filtration, the wet filter cake produced by filtration of currently generated neutralized raffinate would also be dumped into Pit 5. It is presently being dumped into Pit 3 which is almost full. It has been estimated that the additional storage volume required after Pit 3 is filled will be about two million gallons or 267,000 cubic feet.

There are several undesirable or potentially troublesome features in this general scheme. A relatively thick slurry has to be pumped from Pit 5 to Plant 8. The solids content of the pumped slurry is much higher than that of the slurry which was originally pumped to the Pit. It has not yet been shown that existing centrifugal pumps will handle the slurry. Difficulties have been indicated with the failure of two centrifugal pumps (one at the pit and a smaller one at Plant 3) to move some of the underlying sludge. (I suspect that a gelatinous layer builds up on the impeller or volute to choke off the flow.) A diaphragm pump will certainly pump the material, but it may have to be purchased. The worst problem is devising a low-cost method of returning filter cake back into the pit. Another poor feature is that the returned volume of filter cake will be at least 40% of the volume of the pumped Pit 5 sludge. Only liquid would be removed from Pit 5 and the returned filter cake still holds a very high percentage of this liquid. Another factor that should not be neglected is that, during the time period that Pit 5 slurry is being pumped to Plant 8 for filtration, a quantity of rain will fall on the pit and a certain amount of water will be lost by evaporation. If the Pit 5 slurry removal extends over the winter months, there will be a net gain of water which will unavoidably be pumped off with the sludge, thereby increasing the total slurry pumping and filtration load. During the summer months, evaporation will probably exceed the rainfall so that less total pumping and filtration is necessary. After sufficient pit volume is made available for future neutralized raffinate filter cake, the net gain of water from rainfall should no longer be a problem, since it then can be allowed to build up as a supernate on top of the settled solids until it overflows the clearwell or is siphoned away.

ALTERNATIVE SOLUTION: ABOVE-GRADE STORAGE OF FILTER CAKE

It is proposed to store the estimated volume of 267,000 cubic feet of future filter cake on a prepared, raised, area of ground, the surface of which would lie well above the sub-surface water table. A peninsular area would be formed by bulldozing earth from around the area towards the center so that the storage plot would be raised at least two feet above grade and domed slightly (see sketch of Figure 1). The objective is to produce a well drained, firm, storage area and raised roadway upon which loaded trucks can travel in the wet season of the year. After compacting the earth on the raised area, a layer of coal ash at least one foot deep is laid down to aid in surface drainage and produce a surface which is not muddy in wet weather.

The filter cake from Plant 8 would be dumped on this area with care being taken to deposit the material uniformly in depth and as compactly as possible. If the dumping area is one acre, 267,000 cubic feet of wet filter cake would average 6.1 feet in depth. As the material eventually dries out, it would shrink in depth to a minimum of approximately 2.5 feet. It is visualized that the partially dried filter cake would eventually be graded, and composited to form a sloping dome. Then it would be waterproofed by applying a thin asphaltic layer. This, in turn, would be covered with a layer of topsoil and planted with grass.

WHY ABOVE-GROUND STORAGE AS OPPOSED TO PIT STORAGE?

1. The most important reason for proposing above-ground storage is to prevent influx of ground water into the stored filter cake since it is hoped to dry the material to the greatest extent possible. With above-grade storage the only significant water input which must be contended with would be that from precipitation.

2. Placing the material above-grade minimizes the amount of earth movement necessary to store a given volume of waste provided the waste material is piled to a moderate depth. In the proposed case, the ratio between volume of earth moved to initial volume of wet cake stored is about 2. This is based on building a base two feet thick above grade, storing a 6-foot depth of the cake, and placing about one foot of earth on top. If viewed on the basis of the ratio of volume of earth moved to weight of dry solids in the stored material, the above-grade storage is far more favorable than that for Pit 5. This is due, of course, to the much higher solids content of the filter cake in comparison with the dilute slurry in Pit 5.

3. Since the proposed storage of filter cake is above grade, I see no reason for installation of an impermeable base such as clay or rubber sheeting. The filter cake in time will be reduced in water content to a point at which it will not leak significant amounts of water into the ground. As will be discussed later, it is also expected that rainfall will not be a significant cause of leaching. If there is some concern about possible leaching of readily soluble constituents such as nitrate from the filter cake, this can be practically eliminated by incorporating a light wash on the rotary vacuum filter in Plant 8.

4. Another important reason for above-grade storage is the relative ease and cost of "retirement" of the facility in comparison with below-grade pit storage. I visualize retirement of an above-grade storage facility as requiring a relatively small amount of grading to produce a smooth compacted cone or dome. It would then be covered with a thin layer of bituminous material as waterproofing to prevent significant penetration of rainwater into and through the stored solids. Then it could be covered over with earth and planted with a hardy strain of grass or vegetation to prevent erosion.

   I do not know how Pit 5 is to be "retired," but it is obvious that it will be an expensive, drawn-out, proposition! Retirement of Pit 3 appears to be less difficult simply because the material in it has been dewatered to a higher degree than that in Pit 5. Nevertheless, I question that adequate ground stability will ever be attained after the entire pit is covered over with a layer of ash and earth and when it is no longer possible to pump drainage water from its south end.

ABOVE-GRADE STORAGE:

1. Emplacement of the Filter Cake

   The filter cake produced in Plant 8 on the Oliver rotary vacuum filter has the consistency of a heavy slimy paste. It will pile up with a high angle of repose, but when it is unloaded from a dump truck into a trench, it slides from the tilted bed in a sudden rush and spreads out considerably as it hits the ground with a big splatter. This is not much of a problem when the material is being dumped into a below-grade pit, but for storage above grade, it becomes necessary to be able to emplace the material to a depth of about 6 feet, and simple dumping from a truck cannot accomplish this. If the material is dumped on flat ground, the kinetic energy developed from the sudden fall of several feet will probably spread the material to a depth of about a foot and would inundate the rear wheels of the dump truck. How then can the filter cake be piled to a depth of 6 feet in a neatly contoured fashion? I have attempted to illustrate in a series of sketches how I think the material can be handled. Near one end of the raised storage area two circular, diked, catch basins about 30 feet in diameter are bulldozed up with the dike walls raised about 3 feet above the level surface. A raised ramp of earth leads into each catch basin, and the trucks are backed up onto these ramps, which are at the height of the dike walls, for dumping. A mobile crane with clamshell is then used to pick up the filter cake from the catch basins and place it neatly to a depth of six feet in the area adjacent to the catch basins. When the piled material encroaches too closely on the two catch basins, another set of perhaps three basins are prepared as shown in the second sketch, and the first two are leveled. Piling continues around these new catch basins until they too are encroached upon too closely. Finally, a single basin is constructed as shown in the third sketch. It is located at the edge of the storage area near the point where the access road joins the raised storage area. Filter cake is distributed from this final drying basin to the zone previously occupied by the set of three basins shown in the second sketch.

2. <u>Dewatering and Drying of Stored Filter Cake</u>

The filtered lime-neutralized filter cake from the Plant 8 rotary vacuum filter still contains a very large water content after filtration. A drying test on a sample of the cake indicated a dried solids content of about 30.8 weight percent when drying was completed under a heat lamp. The density of the initial pasty material was measured as 71.7 pounds per cubic foot and the material will contain about 49.6 pounds of evaporable water per cubic foot. A column of the stored material six feet high with an exposed top surface area of one square foot would weigh about 6 x 72 = 432 pounds initially and would contain about 298 pounds of evaporable water. The laboratory drying experiment indicated that the material would stiffen sufficiently after a weight loss of about 20% so that a man could walk on the material without his feet sinking into it. This translates to a drying loss of 14.4 pounds of water per cubic foot or 6 x 14.4 = 86.4 pounds of water per square foot of area covered by the material. It is equivalent to the evaporation of a depth of free water of 13.9 inches. It was also estimated that a drying loss of 35 weight percent would render the material dry enough to support heavy equipment. This translates to a water removal of 25.2 pounds of water per cubic foot or 151 pounds water per square foot of area covered by the material, or a depth of 24.2 inches of free water.

An evaporation equivalent to 24 inches of water depth is just about the amount of net evaporation I have estimated should be possible during the five hottest months of one year. By "net" evaporation is meant the difference between loss of water brought about by solar heat input and convective air drying less the gain of water from rainfall.

Piling of the filter cake onto the storage area must be conducted on a year-round almost daily basis. On the average, it is estimated that about 33 cubic yards of cake must be piled each operating day which would cover an area of 150 square feet to a depth of six feet. During the colder seven months of the year when there would be practically no net evaporation drying of the cake, it is proposed to cover the stored material with plastic sheeting in such a way that most of the precipitation falling on the material will be drained off to the sides.

Numerous evaporative drying tests in the laboratory with Pit 5 filtered sludge and Plant 8 filter cake have shown that water removal proceeds at a nearly constant rate per square foot of exposed drying surface until a large percentage of the total moisture is removed. As drying proceeds, the exposed surface remains saturated as the water diffuses to the surface. The evaporation rate is therefore very much the same as that expected from a free water surface. A necessary consequence of this type of drying is that the material shrinks in volume and the shrinkage volume decrease will nearly equal the volume of water lost by evaporation until the final stages of drying are reached. The total shrinkage is very great. The sample of Plant 8 filter cake studied in the drying test referred to previously shrank to a final volume of only 41% of that of the wet filter cake. Final dry density was 54 pounds per cubic foot. Most of the volume decrease will have taken place by the time that approximately 60% of the water has been removed by evaporation. Addition of water to the partially or fully dried material does not result in appreciable swelling or decrepitation. In other words, the shrinkage is irreversible. The fully dried solids are porous as is evident from the low bulk density of only 54 pounds per cubic foot, and the material will reimbibe a relatively large amount of water readily to fill the vacant pores. As an example, a sample of fully dried Pit 5 sludge having a density of 52 pounds per cubic foot increased in weight 72% when it was immersed in water, but it did not swell noticeably. The weight of water held by reimbibing was only 39% of that originally held in the well-drained, pressed, filter cake.

In above-ground storage, the intention is to dry the stored material as thoroughly as proves practical under outdoor conditions. The goal would be to evaporate approximately 60% of the moisture since this would leave the material in a very firm condition and will have accomplished most of the shrinkage. To accomplish this degree of moisture removal, the material will have to be exposed to two summer seasons of hot weather from say May 1 to September 30. Then it should be covered over with plastic sheeting to permit draining off most of the precipitation which would fall on it in the colder seven months of the year. Final retirement may consist of bull-dozing the material into a more steeply sloped dome, compacting, coating with a thin layer of asphalt to minimize rainwater percolation, covering with topsoil, and planting with grass.

As indicated previously, if the 2 million gallons of filter cake were dried to near maximum density, the volume would be reduced 59% or to about 110,000 cubic feet. If this volume is bulldozed up into a cone with 20° slope, the height at the center would be 24 feet and the diameter of the base would be about 132 feet. The area covered by the base would be 0.31 acre. Piling in this manner would greatly reduce the area of land covered by the material, lessen the area over which asphalt waterproofing is required, and would aid in providing better run-off of precipitation.

It may be of interest to estimate what storage volume would be necessary if the 20 million gallons of Pit 5 material, having an estimated solids contentof 12 weight percent, were similarly stored in a partially dried state. The total volume of stored solids would then be about four times that resulting from the 2 million gallons of Plant 8 filter cake containing 31 weight percent solids. This could be stored in a 20° sloped cone having a height of 38 feet, a base diameter of 210 feet, and a base area of 0.80 acre. (Actually, the peak of the cone would be flattened so that the center height might be about 30-35 feet.)

3. Leaching Considerations

The storage method outlined above should reduce to a minimum the loss of water-leachable contaminants to the environment. This is done by reducing the flow of percolation water through the stored material to an absolute minimum. In below-grade pit storage where at least a portion of the material is below the surrounding subsurface water table, and where the ground surface has not been sealed against rainwater percolating downwards, there must be a balancing flow of water through the stored material and into the subsurface water table. Since no chemical compound or adsorbed contaminant is completely insoluble, there must be at least a gradual subsurface spread of the contaminants.

The storage of solid wastes containing radioactive species has been heavily researched at numerous AEC facilities. The technical approach taken has always been (1) consolidation of the waste into the smallest practical volume by methods such as evaporation or calcination (2) encapsulation to resist physical deterioration as by casting in concrete or vitrification on clays, and (3) storage in geological formations which preclude contact of the stored material with water as by storage in underground salt formations. I believe the proposed above-grade storage embodies these general principles to a high degree and is preferable to the method which has been practiced at this site.

CONTROL OF EROSION SPREAD OF FILTER CAKE SOLIDS

During the summer months when the piled filter cake is not covered with plastic sheeting, one may have to consider the effect produced by a heavy "gully washer" rain which may dump as much as 2 or 3 inches of rainfall onto the storage area within an hour or two. Some of the water would soak into the filter cake, and much of it would be entrapped in shallow pools on top of the stored material where it will eventually soak into the cake or remain until it is evaporated later. Also, some fraction of the water will flow off the material at the perimeter of the storage area. This water will entrain some solids in suspension and tend to carry these away from the storage area and into the drainage from the surrounding area. This spread of the filter cake solids is undesirable and should be minimized. I believe this erosion spread of solids can be practically eliminated by doing two things. First, by piling up the filter cake a few inches higher around the periphery of the bed, the rainfall can be trapped within the shallow dike formed by the cake so that it cannot run off carrying solids with it. Secondly, rainfall running down the slopes at the perimeter of the stored solids could be trapped in ditching formed by piling porous sand around the periphery of the stored cake as shown in Sketch No. 3. The drainage carrying some solids is trapped briefly in the ditched depression but the water quickly soaks into the sand leaving the solids filtered on the sand.

When the drying season is over and the stored solids are to be covered with plastic sheeting, it will be necessary to level the shallow dike around the periphery of the stored filter cake so that drainage away of the precipitation falling on top of the covered area is no longer hindered.

IMPLEMENTATION OF THE CAKE STORAGE SCHEME

I do not believe the above-grade storage scheme outlined in this letter requires any further time-consuming development, but should be directly committed to full-scale practice. To get started, I would survey the area where the storage plot is to be placed and begin the grading work. The whole area need not be graded immediately, but only the southern third of the above-grade storage area and access roadway need be bulldozed up, compacted and layered with ash. Then cake piling could be begun as shown in Sketch No. 1. We can then evaluate the details of operating technique under fully realistic conditions. For example, we may wish to test out the procedure for laying down large sections of plastic sheeting over the material when it is still wet to see if there are any insuperable difficulties. We can also study the drying rate of the piled filter cake to determine how well this agrees with estimates based on calculations from drying theory.

If at any time, the scheme proves to be impractical, very little has been lost. The filter cake can be reloaded into trucks and dumped into Pit 3 (if some space is still available) or returned to Pit 5.

Gifford G. Briggs
G. G. Briggs

GGB/rlr

cc: W. J. Adams - R. C. Kispert
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R. C. Heatherton
N. R. Leist
J. B. Patton
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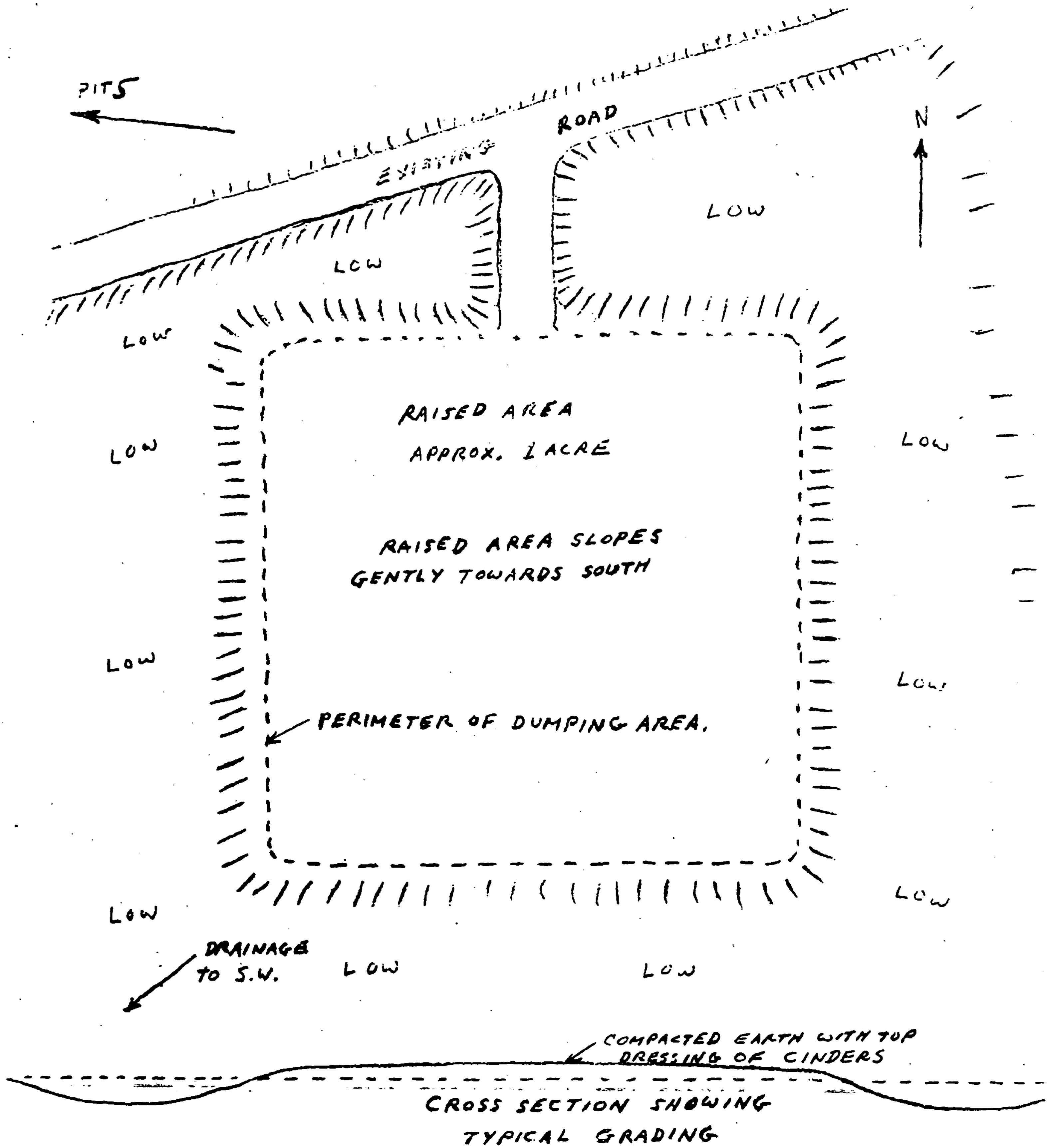
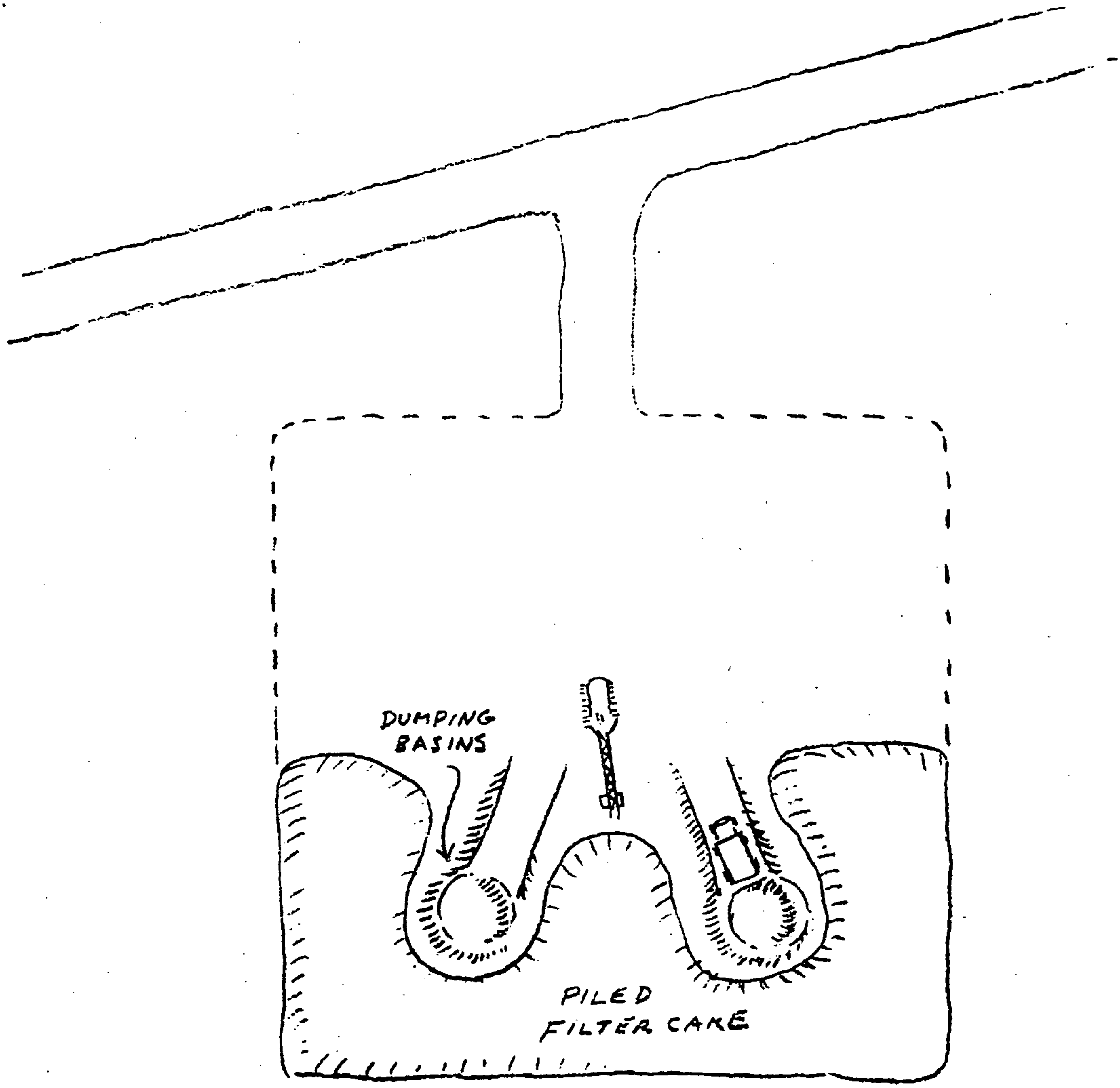
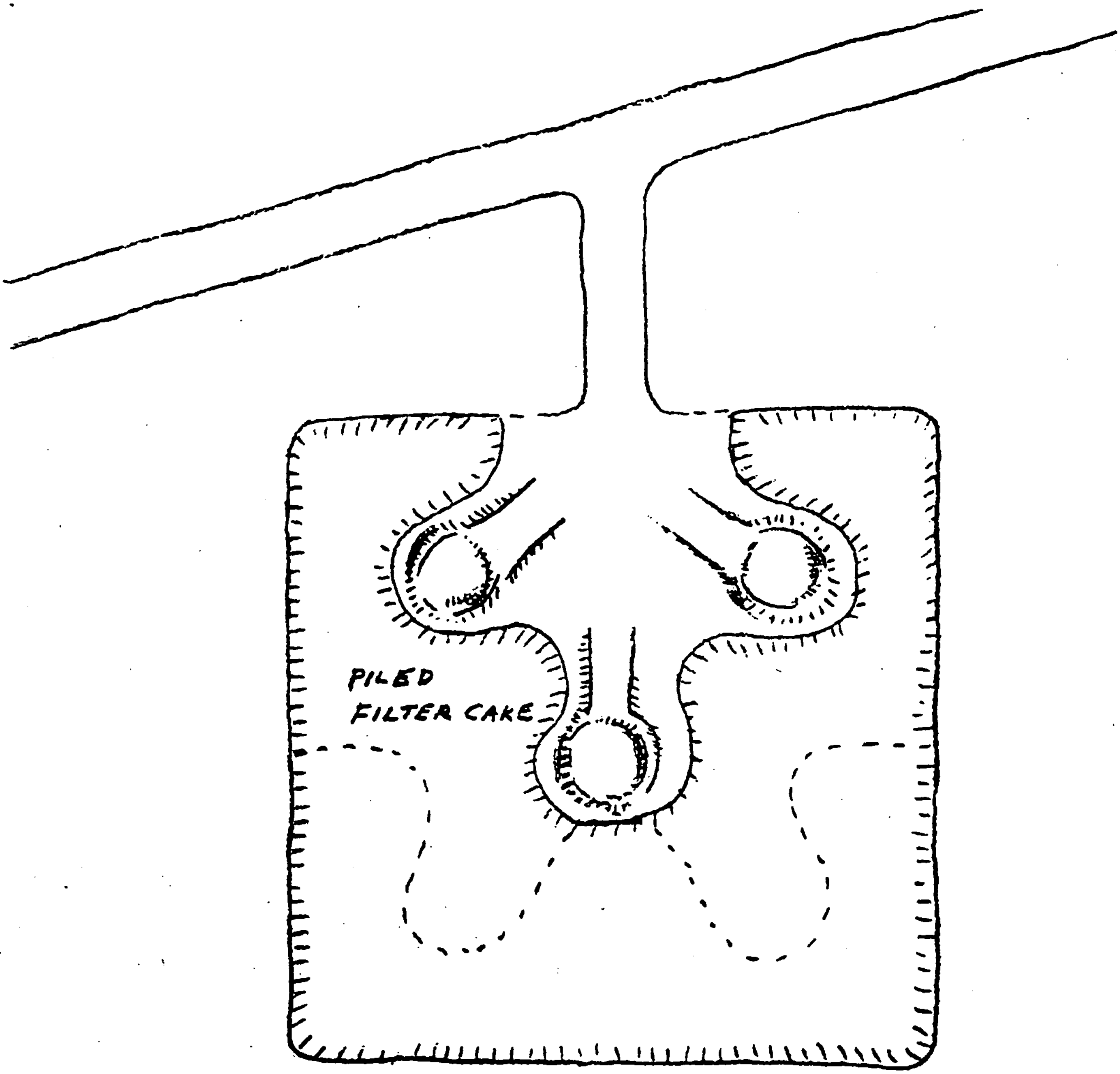


FIGURE 1: ABOVE-GRADE STORAGE AREA



SKETCH #1



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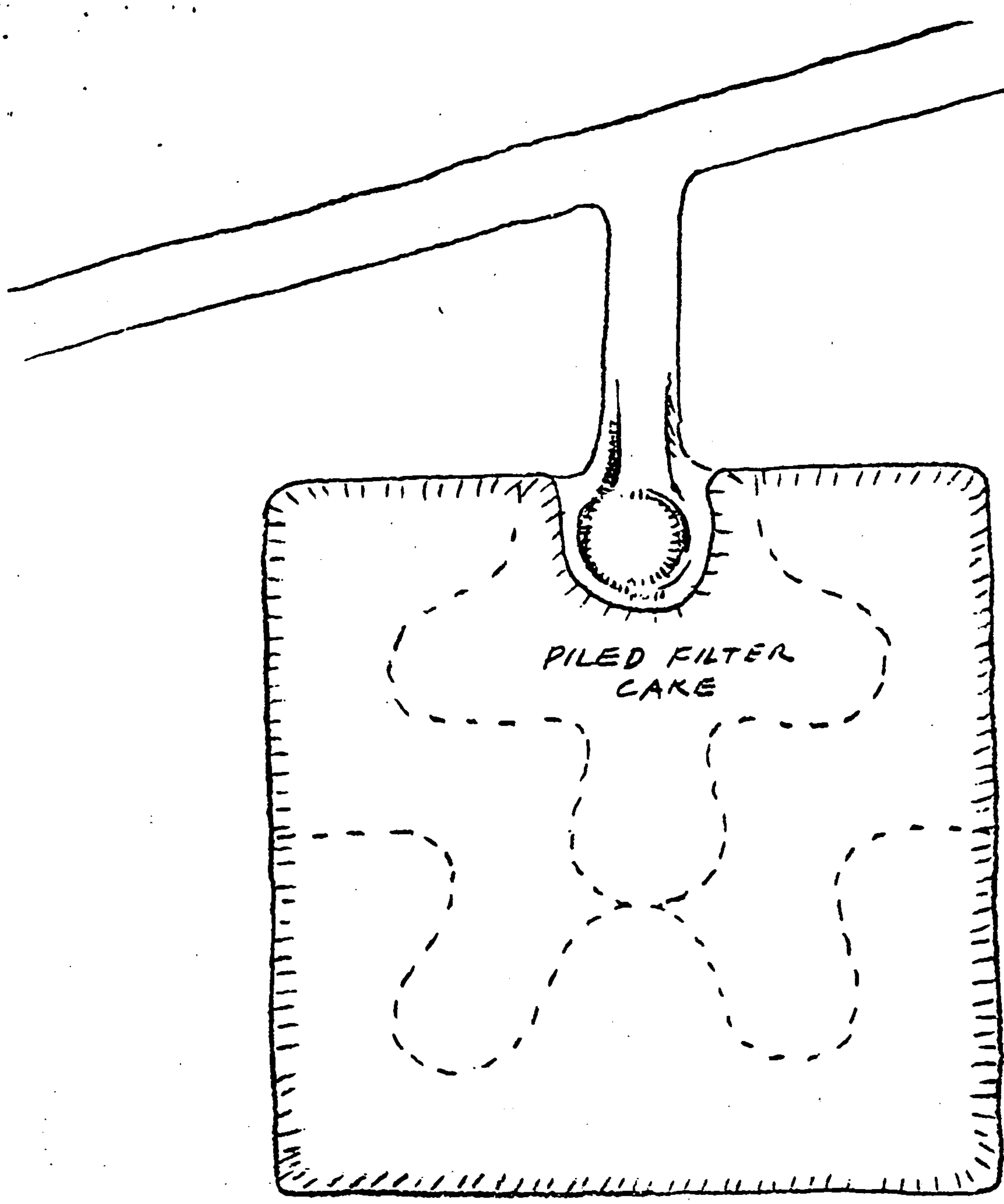
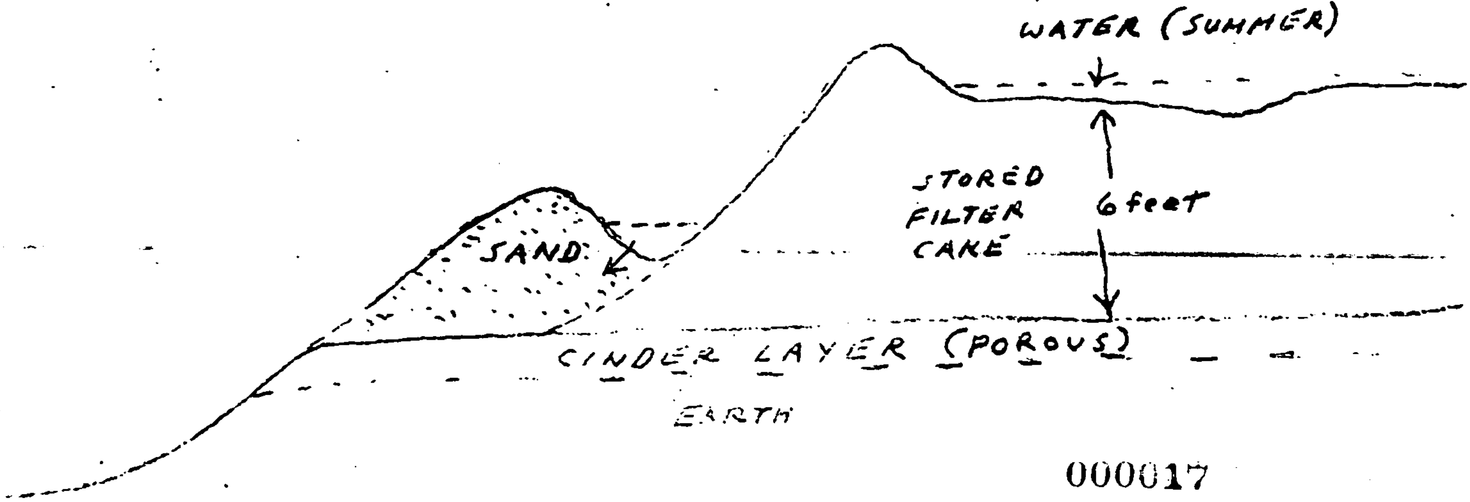

PILED FILTER
CAKE

SKETCH #3


TRAPPED RAIN
WATER (SUMMER)
STORED
FILTER
CAKE
6 feet
SAND
CINDER LAYER (POROUS)
EARTH